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Treatment of the Combined Sludges of Machine Factories

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Abstract

The article presents the basic characteristics of composition and formation of combined sludges of steel mills, machine and metalworking factories. The principal issues of use of flocculants in dewatering of combined sludges of industrial wastewaters are stated. The article dwells upon the issues of a flocculant selection for treatment of industrial wastewaters of machine factories, and creation of optimal conditions for flocculation sludges processing. The problems of handling and disposal of sludges produced by industrial wastewaters treatment facilities are considered. The main purpose of this research is assessment of the possibility of advanced flocculation technique application for the treatment of combined sludges.

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Keywords: industrial wastewaters treatment; combined sludges; flocculation; dewatering; utilization

1. Introduction

With the development of industry all over the world water consumption is constantly increasing [1, 2] and requirement for water conditioning and industrial wastewaters treatment, and, consequently, increasing the amount of sludges [3, 4].

It is necessary to create a system of comprehensive assessment of the produced sludges, which would determine the best conditions for sludges obtaining for dewatering and further processing. The formation of sludge with the desired properties starts with the selection of industrial wastewaters treatment, that ensures the recycling or safe storage of sludge, reducing costs for its dewatering and drying [5, 6]. Complex assessment of sludges properties is a very sophisticated problem due to diversity of its properties and complexity of recycling [7, 8].

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2. Sludges classification

The properties of sludges are mainly determined by the composition of its components and conditionally can be divided into three categories: mineral, organic and combined. Sludges are always quite a complex mixture of various substances; therefore it makes sense to speak about dominating components. Great importance has phase — disperse structure of the sludge substances. Since in practice sludges are often formed, the main operation of its processing is dewatering. Accordingly, sludges are conventionally divided into three types by their water loss: easy-, medium- and hard-filtered.

Easy-filtered sludges consist mainly of crystalline or large amorphous particles and moisture is removed easily even without the pressure difference on filter media. Dewatering equipment is necessary for the intensification of technological process and the convenience of its implementation (for example, for the isolation of crystalline heptahydrate of iron sulfate). Medium-filtered sludges consist mainly of fine crystalline or amorphous anhydrous mineral particles (or its mixture) and can be dewatering without external influence, but with a low speed and low final water content of sludge, which is often insufficient for further processing. Dewatering equipment is necessary to eliminate these disadvantages. Typical examples are sludges of gas scrubber water in steel industry [9].

It should be noted that dewatering of these types of sludges cause no problems. Schemes of sludges conditioning for dewatering, and the dewatering process are worked through. Hard-filtered sludges include combined sludges received at sludges of steel mills, machine and metalworking factories. These sludges contain [10]:

- solvents wastes;
- spoiled or contaminated metalworking fluids;
- painting wastes;
- case-hardening spent baths and spent packing when pack carburizing is used;
- spent plating and processing baths and their wastes, such as anode sludges and hot dip dross;
- oils and suspended solids separated from cleaning baths;
- wastes originating from recovery and reuse applications: filter wastes or cartridges used for pretreatment of ion exchange or adsorption operations, evaporation residues, still bottoms, membrane filter concentrates, wasted treatment material such as resins, and adsorbants, etc.;
- scrap metals mixed with metalworking fluids or contaminated by other hazardous wastes;
- exhaust scrubber blow down;
- treatment sludges containing toxic metals.

Combined sludges have all disadvantages of its compounds, because of large number of fine particles, including watered flocculent constituents (e. g., metal hydroxides), a lot of organic components. The particles sizes in combined sludges vary from suspended particles and colloidal systems to soluble components. Such combined sludges should be processed and dewatering.

3. Hard-filtered combined sludges treatment

3.1. Properties of hard-filtered combined sludges

Volumes of the most often encountered hard-filtered sludges of metals hydroxides are determined by the content of unstructured water. It`s quantity mainly depends on the dispersion of sludge: the higher sludge dispersion, which is determined, for example, by microscopic methods, the more they watered. For metal hydroxides the amount and dispersion of sludge increase in the number of anions $NO_3^- \rightarrow Cl^- \rightarrow SO_4^{2-}$. In theory and practice of conditioning of sludges the term "sediment structure" is often used, it contains data about macro- and microstructure. The first of them characterizes only the phase composition and dispersion of sediments. The microstructure refers to the size of the lattice parameters of the hydroxides and the most typical elements of their layered structure — the distance between hydroxyl groups of neighbouring (adjacent) triple layers. A significant influence on sludges properties has the presence of organic components [11]. They generally contribute to the increase of specific resistance to filtration of filter cake [13-15] and especially specific resistance to filtration of the filter media [16]. In case of use of surface filters for sludges dewatering rapid clogging of the filter media occurs. When using centrifugal equipment the discharge of sediment from the centrifuge or separator will cause complications.

3.2. Hard-filter combined sludges flocculation and dewatering

The first problem of combined sludges is a problem of dewatering. As sludge belongs to the category of hard-filtered, for dewatering process additional chemical treatment of combined sludge by flocculation [17, 18], that is, the structuring of sediment, is required. In the selection of flocculent it is necessary to define the charge in the hard-filtered combined sludge. To do this, using physical and chemical methods to determine electrokinetic potential and the total charge, this will depend on the quantitative ratio of the combined sludge structure. The dependence of the efficiency of water purification from the charge value reveals the stronger, the lower molecular weight of flocculants. When the process of flocculation is carried out properly almost all flocculent "leaves" to the cake.

If the conditioning of sludge is not provided, the flocculent is added before dewatering. There are technologies, where the added flocculent "is shared" — part is added to the sludge before thickening, and other part — before the dewatering (so-called fractional flocculating). Resolution of high-molecular substances in water proceeds slowly. Initially swelling the polymer occurs, and then starts formation of homogeneous solution as a result of mutual diffusion of the water molecules and macromolecules of polymer. These processes can be accelerated by heating and non-intensive, in avoidance of destruction, stirring.

When selecting the concentration of working solution of flocculant for conditioning quite dilute solutions — 0,05–0,1 % can be used, since the clarified water removal during condensation is realized very simply. But during sludge dewatering (especially mechanically dewatering) it is desirable to have a working solution with concentration of flocculant of 0,25–1 %. "Excess water" flowing to the sludge with the flocculant is removed from the system is quite difficult. Of course, in each case, flocculation technology should be thoroughly tested in laboratory.

Sorption of flocculants should proceed slower due to the large size of macromolecules. Intensive stiring minimizes the time of reaching of adsorption equilibrium. With intensive stirring, a maximum of adsorption is reached after 1–2 min. Increase of the stirring duration above the optimal leads to desorption of the polymer from the surface of the particles, which increases with decrease with the content of dispersed phase in the treated water.

Based on these ideas about the mechanism of flocculation, the flocculation properties of organic flocculants will be determined by the following factors [19]:

- physicochemical characteristics of flocculants (molecular weight, presence and degree of dissociation of ionogenic groups);
- physicochemical characteristics of treated water (nature, degree of dispersion and concentration of removed contaminants, the presence and nature of dissolved substances);
- technological parameters of flocculation (mixing and flocculation).

3.3. Hard-filter combined sludges utilization

It is important to note another problem of combined sludges — it is the problem of utilization. Dewatered sludges must be utilized. Utilization is any sludges treatment for further beneficial use, storage and destruction. Of course, the best solution would be utilization, but sludges are substandard raw material and constantly changing product, often quite toxic, corrosive, flammable, etc. Therefore, approaches to the problem of sludges treatment should be based on the fact that the evacuation of untreated sludges is extremely dangerous to the environment, which accepts it in this form. A huge variety of sludges and methods of their processing are formed in industry. Completely eliminating the environment pollution is the method of thermal drying at temperatures 800–1300 °C [20, 21]. However, this utilization process is characterized by high energy costs and cannot be widely used yet.

The most rational and the most perspective direction of the use of inorganic sludges after thermal processing, according to their composition and content of useful components, is the production of construction materials [22-25]. It is used as additive to asphalt-concrete mixtures, in manufacturing of clay bricks, in the manufacturing of haydite (containing 20 % of sludge can be used as insulating and construction material), in the manufacturing of various pigments, in the manufacturing of glass-ceramics, of glass marble (shock resistant glass, thermo- and frost resistant glass), in the manufacture of tiling, etc.

4. Conclusion

Sludges almost always represent polydispersed systems in that fine fraction form the hard-filtered sludge. It is necessary to pay attention to hard-filtered combined sludges, because all of them (even the so-called "model") require an individual approach: testing of conditioning parameters, selection of dewatering equipment and technological parameters of the process. When choosing of methods and equipment for processing of combined sludges of steel mills, machine and metalworking factories the composition, quantity, price and environmental safety play an important role. Quantity of industrial wastewater sludges constantly grows, and today it is a major polluter of environment. Hence, high importance of the development of technologies of industrial wastewater sludges processing arises.

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